

Do you think there is a difference between the amount of gas used to fill a balloon for the Thanksgiving Day Parade compared to the same one used for the Fourth of July Parade?



Behavior of Gases

Volume

- 1.The amount of space it takes up
- 2.Depends on the shape of the container.This is because the particles of gas can be **compressed** or squeezed together
3. Example- balloon animals-filled with air not water.



Temperature

1. measure of how cold or hot something is or
measure of the movement of particles in an object
2. The higher the temperature- the more energy,
the more energy- the faster the particles



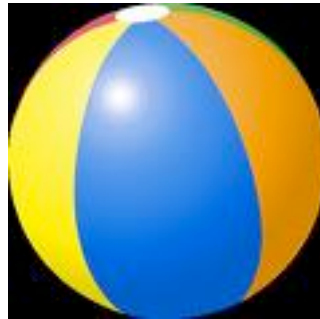
November in New York



July in Washington

Pressure

1. the amount of times a gas hits the inside of its container
2. More hits from the particles= more pressure
3. Example
Basketball vs. Beachball



can hold the same volume of gas but the particles inside the basketball hit its insides many, many more times. That is why it has more pressure than the beach ball.

Scientists found that volume, temperature and pressure are linked.

Boyle's Law

1. As pressure increases volume of gas decreases
2. As pressure decreases volume of gas increases
3. Indirect Relationship
4. Crushing a balloon- increases pressure but decreases volume.
Letting it go –decreases pressure and increases volume

Charles' Law

1. As temperature increases, the volume of gas increases
2. As temperature decreases the volume of gas decreases
3. Direct Relationship
4. Tires in the summer will look deflated in the winter while they will look inflated in the summer

Story of Charles' Law

To begin the story of Charles law, we should first look at the early attempts of discovery by Robert Boyle and Guillaume Amonton. In 1622 Boyle had published his work on the inverse relationship between a gas' pressure and volume, a law that would later bear his name. He was aware of the increase in volume of a gas when heated, but a temperature scale did not exist then. In the early 1700's Amonton did many experiments involving a gas' volume and its temperature, but like Boyle a temperature scale did not exist. (Thall, n.d.)

So we can now look at the gentleman who the law is named after. Jacques Charles was a Frenchman who early on in his life had very little science education. While working in a Paris Government Office he had a chance encounter with the American Ambassador to France, Benjamin Franklin. After hearing of Franklin's experiments and scientific ideas, Charles decided to teach himself some science. This self teaching eventually led to public lectures and then to the Academy of Science, where he began to develop a respectable reputation. (Ellyard, 2005)

It was here in 1783 that the Montgolfier brothers asked Jacques to look at their new mode of travel, the hot air balloon. After careful scrutiny, Charles stated that he believed that for the safest and surest form of travel the balloon should be filled with "a very light flammable air (hydrogen) rather than heating the air over fire." (Ellyard, 2005) In August of that year he put his theories to the test. He got his first balloon and filled it with hydrogen by pouring sulfuric acid over scrap iron (later zinc). He went to a field, where the Eiffel tower now stands, and sent his balloon up 10 km. After more trials he soon started to notice that the balloon's volume would expand as the balloon went up into lower air pressure. This was not anything new; it was simply proving Boyle's Law from 1659. More importantly he saw a connection between heating the gas and the gas; volume. (Ellyard, 2005)

In 1787 Charles decided to investigate this relationship further. He went out and got a J-shaped glass tube that Robert Boyle had used in his study of gases. He placed the tube in a water bath so he could manipulate the temperature of the gas. He held the pressure of the trapped gas bubble steady by "keeping a constant difference between mercury levels in the two arms of the tube," (Ellyard, 2005) This would make pressure a non factor in his experiments. He then went about changing the temperature of the water bath and observing the effect on the trapped gas bubble. His results showed that

the volume of the gas rose with an increase in temperature and fell with a decrease in temperature, (Ellyard, 2005)

This relationship was dubbed Charles' Law. This may not be fair for two reasons. First Charles was not the first to discover this relationship. Gulilliam Amontons had done so in 1702, but Charles' apparatus was better and he had more precise measurements. Secondly Charles never published his work on the relationship between a gas' volume and its temperature. That distinction would go to Gay Lussac. (Ellyard, 2005)

After the French Revolution, fourteen year old Joseph Gay-Lussac went to Paris. It was here that he received private lessons and attended boarding school. He eventually became an assistant to French chemist Claude Louis Berthollet who trained him in chemical research. During the winter of 1801-1802, twenty-four year old Gay-Lussac was encouraged by Berthollet to conduct research on the expansion properties of gases. (Green, Peterson, 1992)

Gay-Lussac wanted to get results that were more accurate than those obtained by Charles and others. In his experiments he "excluded water vapors from his apparatus and made sure that the gases themselves were free of moisture.". He concluded that "equal volumes of gases expand equally with the same increase in temperature."(Lussac, 1802)

There were some differences between his results and Jacques Charles. First of all, Gay-Lussac published his results while Charles did not. Gay-Lussac also measured the coefficient of expansion while Charles did not. Charles only investigated oxygen, carbon dioxide, nitrogen and air. Gay-Lussac's results worked for all gases. Finally, because Charles has water in his apparatus, his results showed an unequal expansion for the gases that were water soluble. Gay-Lussac had obtained more accurate results and published them yet the law is still more commonly referred to as Charles' Law as opposed to Gay-Lussac's Law. (Green, Peterson, 1992)

Like Charles before him, Gay-Lussac was an avid balloonist. In 1804 he flew to an altitude of 23,000 feet which was a record that stood for half of a century. Eventually as, Charles predicted, hot air balloons were replaced by hydrogen filled and later helium filled balloons. In the 1960's hot air ballooning became popular again as a sport. (Reese, 2004)

Charles and Gay-Lussac's results helped other scientists discover the absolute zero temperature of a gas. This is done by locating the theoretical temperature in which gas has a volume of zero. (Ellyard, 2005) This is the coldest temperature possible. It has never been achieved because gas liquefies before reaching this temperature and is no longer subject to the gas laws. (McGrath, 2005)

Pictures

Charles



Gay-Lussac

Links

<http://www.grc.nasa.gov/WWW/K-12/airplane/aglussac.html>